THE BENEFITS OF COMBINING SOLAR AND STORAGE IN MICROGRID APPLICATIONS

CLEANSPARK
SOFTWARE

Amanda Kabak, CTO CleanSpark, Inc. | August 28, 2020

ENERGY STORAGE can be a valuable addition to a renewable energy developer's toolkit and provide significant value to end consumers, utilities, and everyone in between.

Introduction

Renewable energy has evolved and expanded significantly over the last two decades into a force in both the environment and the economy, but such gains have not been without its fair share of growing pains. Despite exponential growth, the solar energy market is now faced with a new set of challenges. Most notably, solar-only installations have seen a decline in ROI as utility companies shift their peak rate schedules to when solar generation is tailing off for the day. The good news is that a multifaceted, functional solution exists for this and other issues across the renewable ecosystem. With cutting-edge technology, solar and advanced energy storage can be combined within a network of intelligent controls to provide reliable, affordable, and optimized power to energy consumers. Today's microgrid applications are both flexible and adaptive, enabling the end user's energy systems to generate a marked improved return on investment. To truly grasp the importance of this innovation, let's now examine how the renewable landscape has evolved and the leading role microgrid technology plays in the future of energy.

What are Microgrids?

Microgrids might be the hot "new" thing in energy, but the term can be vague—or even downright confusing. How small is "micro"? Do they always include renewable energy? Do they have to be connected to the grid? What happens if more energy is produced than consumed? The powerful and difficult thing about microgrids is that they can vary widely in both the makeup and size of equipment in the installation and the way the energy produced is used. So, first, let's establish a baseline definition:

> A microgrid is a set of resources used to provide a source of energy distributed from a central utility provider.

Clear as mud, right? First, what do we mean by "resources"? Generally, a microgrid will have a combination of installed equipment that acts as energy producers such as solar panels, turbines, generators, wind, etc.; energy consumers, which are the loads needed for electricity to operate; and prosumers that are resources like battery energy storage systems that both consume electricity to store and later "produce" energy when they discharge. These distributed energy resources (DERs) coordinate together to serve the facility load and, possibly, even participate in larger, external energy markets by potentially reducing utility consumption when a demand response signal is received or by exporting excess solar energy to the grid in exchange for energy credits on their bill. The DERs can also be islanded from the grid and act as a mini utility for a specific site in the absence of service from a centralized utility.

The key element in that microgrid definition is **distributed**, but why is that important? For one, energy is lost during transmission from a central generating facility to the wall socket. While high-voltage transmission lines are relatively efficient, once that voltage is stepped down, the losses compound. The California Public Utilities Commission's 2017 report[i] estimated that as recently as 2015, PG&E had over 8% loss in energy during transmission. The use of high-voltage transmission lines, though they reduce losses, can lead to another problem with centralized power generation: outages. Not to pick on California, but transmission lines there have been linked to several different wildfires, and to try to mitigate this, utilities have begun shutting down their distribution for days at a time in particularly fire-prone areas.

These transmission lines are also a part of the United States' problem with an aging infrastructure. In addition to bridges and dams, long-distance lines for energy transmission require investment in upkeep, and the cost of that upkeep must be passed along to energy consumers. According to the US Energy Information Administration, investment in transmission infrastructure upkeep has increased ten-fold in the last decade[ii]. Utility rates continue to rise, and along with the benefits of energy security, offsetting this cost of purchased energy is another compelling reason to invest in local energy generation and microgrids.

Finally, because of the localized nature of microgrids, they can be designed and programmed to operate in a way that is customized and optimal for the local facility's energy use, which can provide added efficiencies and cost savings.

Renewables Evolution

While the first photovoltaic (PV) cells developed in the late 19th century were about one-percent efficient, and the first modern PV cell produced by Bell Labs in 1954 cost $250 to produce one watt of electricity, PV technology has advanced rapidly in both cost and efficiency. The cost of installing PV has dropped about 20% in only the last five years, and premium production PV panels have now topped the 20% efficiency benchmark. In addition to solar, energy storage technologies continue to proliferate and improve. Along with more traditional lithium ion batteries, the storage market now includes other chemical makeups, electrolyte flow batteries, electrolyte "bath" batteries, and even flywheel-based kinetic storage mediums. Many of these batteries can provide at least 80% efficiency over a full charge-discharge cycle and a useful life of a decade at price points that are cost effective from a return-on-investment standpoint.

Though solar and wind are the two most commonly talked about green energy production technologies, renewable energy sources continue to grow rapidly, including biomass, geothermal, and hydro-based generation. These resources can be deployed at utility scale (large wind and solar farms, for example) as well as within microgrids to provide a growing amount of energy generation outside of the traditional sources of coal or natural gas. As the price of renewable energy sources continue to drop and their efficiencies continue to rise, they will displace more and more traditional generation, reducing greenhouse gas emissions and other waste and preserving our planet's non-renewable resources.

The Changing Utility Landscape

With the rise of renewable generation, utilities have faced several challenges: providing proper interconnection with residential rooftop PV and other microgrid installations, balancing the grid with a mix of steady traditional generation and an increasing amount of fluctuating renewables; the economic and political burden of occasionally having to curtail large amounts of excess power; and pressure from government and regulatory bodies to participate in incentive programs to further increase renewable penetration. To help start the renewable revolution, many states and utilities introduced net-metering programs which provided energy credits for solar generation exported to the utility grid. But, as more renewables have come online, this strategy has become more difficult to manage as the curve of the typical load profile across the utility has changed.

The California Independent System Operator (CAISO) has been tracking their the "duck curve" of actual and projected net loads across their infrastructure (figure 1).

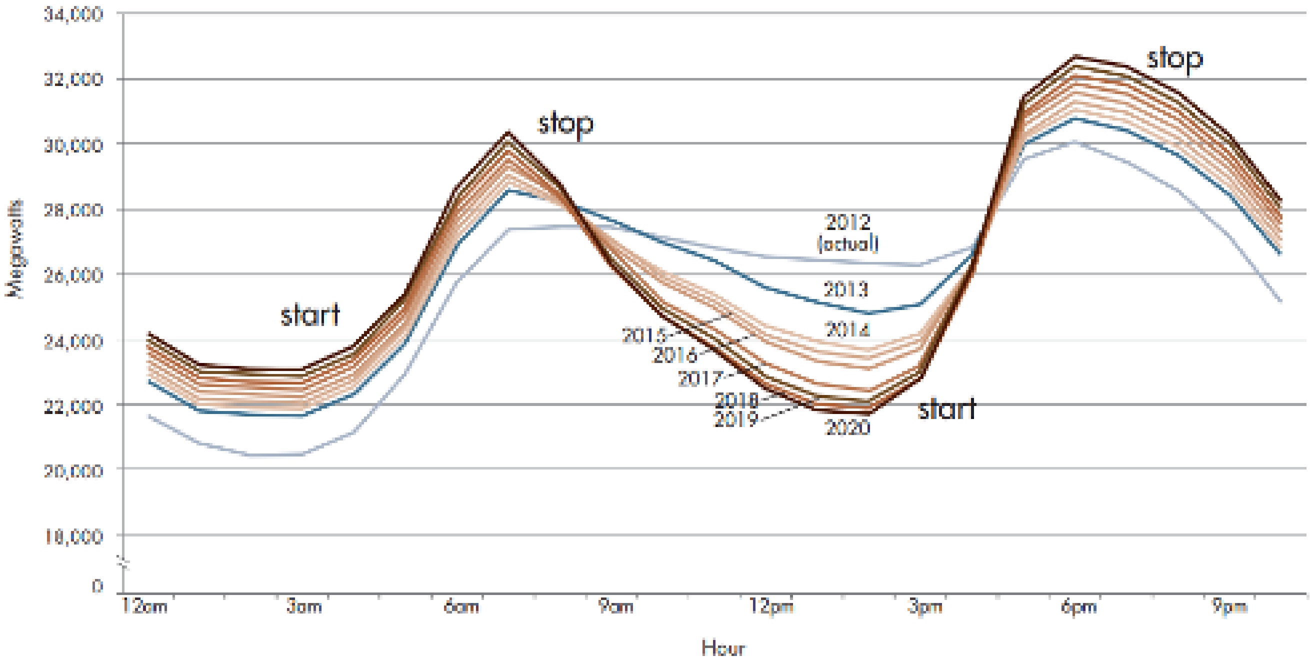

Figure 1: CAISO historical and projected "duck curve"

Plotting their observations and projections, one can see clearly how the rise in solar generation capacity in the state has upended the traditional load curve utilities have been seeing for decades. Note that where there was a relative flatness to the load in the middle of the day, before a rise in the evening hours in 2012, we now see a pronounced dip in the afternoon due to that being the period of greatest solar generation. At the same time, the evening hours are continuing to increase their demand on the grid.

In response to this changing load curve, utilities have begun shifting their "peak" rates later in the day to match the period of the highest net load, when energy consumption has increased but solar generation is tailing off.

What this means is that sites that have done will well economically with solar-only installations are now providing less value because the peak demand seen by the utilities is now during the peak pricing period as well.

DER Coordination

It is the combination of this shift in the peak-pricing time of use as well as the aging transmission infrastructure that makes a coordinated microgrid not only more economically feasible but, in many cases, a necessity. In order to avoid the highest demand charges a utility will levy, facilities must find a way to shift their load profile to avoid the evening peak consumption. This kind of load shifting—and peak demand shaving—can be accomplished by pairing solar generation with an energy storage medium. In this configuration, some of the solar generation that would normally flow back over the meter onto the utility grid for net-metering credits (or even be curtailed if net metering is not allowed), now goes to charge energy storage.

Though there are losses in charging and discharging energy storage, these are more than made up for if the battery is charged from an inexpensive renewable resource and discharged during a peak demand period for the utility. Consider the fictitious scenario of a light industrial facility in the greater Los Angeles area. With solar-only operation, we would see the following energy flows over a typical summer week (figure 2):

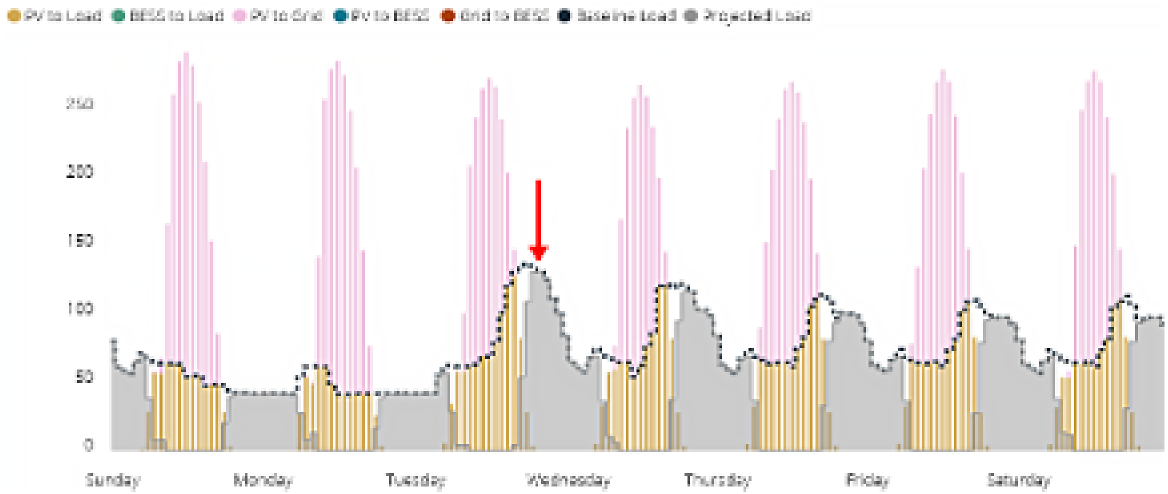

Figure 2: Sample Week of Operation (kWh). Typical solar-only operation generated by CleanSpark's mVSO product

Note the red arrow. PV has run out for the day, but the facility load is still high, causing a peak demand at the very worst and most expensive time. But these peaks can be mitigated with the addition of energy storage. Given the same facility, but combining the installed solar with 450 kWh of storage, we see resulting operation like this (figure 3):

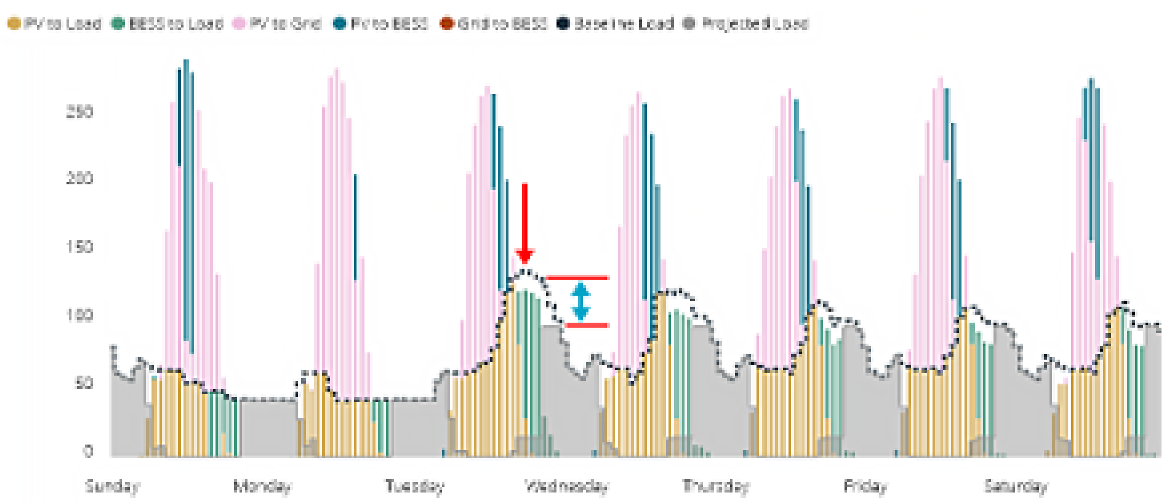

Figure 3: Sample Week of Operation (kWh). Solar plus storage operation generated by CleanSpark's mVSO product

The red arrow indicates the peak demand of the facility, but now we see that it's displaced largely by stored energy discharge—energy that was charged by excess solar generation. The missed opportunity of any foregone net-metering credits and the loss of energy due to battery inefficiency will be more than made up by the reduction in very expensive peak demand charges illustrated by the horizontal red lines and the blue arrow between.

In addition to load shifting and peak shaving opportunities, combining storage with your solar installation can also enable various amounts of energy resiliency by using the charge in your energy storage to carry you through smaller utility outages. Even better, there are many incentive programs available that significantly reduce the up-front capital expenditure involved with installing energy storage as part of a microgrid.

A Project Case Study

For that same fictitious industrial facility in the greater Los Angeles area, the benefit of combining storage with a solar installation becomes clear. The facility has a yearly consumption of approximately 607,000 kWh with a peak demand of 137 kW during a summer on-peak period.

Scenario	*Solar Only*	*Solar + Storage*
Installed Solar	*364 kW*	*364 kW*
Installed Storage	*N/A*	*207 kW/450 kWh*
Project Cost	*$970,000*	*$1,183,000*
Incentives	*$236,600*	*$307,000*
IRR	*12.05%*	*14.27%*
NPV	*$268,000*	*$483,000*
Payback	*7.75 years*	*6.51*

With solar-only, the resulting peak demand is pushed down only 6 kW to 131 kW, but paring solar with storage results in a dramatic on-peak demand reduction to 69 kW and an off-peak reduction of an additional 30 kW. From a baseline utility cost of $135,000, overall first-year operational cost savings increase from $55,900 with the solar-only installation to $80,000 with the addition of storage. Incentives for significantly defray the cost of installing storage. In addition, storage is an integral way to tap into other revenue-generation opportunities like utility-driven demand-response programs.

Optimal Operation

In a combined solar and storage microgrid, the challenge is how to operate these assets in the most cost-effective way for your objectives. While much value can be derived from merely charging storage from excess solar and then discharging during peak utility hours, even this simple algorithm raises more questions: How much storage should be installed? Would it be beneficial to install more solar now that the excess generation can be used for more than rolling back the meter? Would it be valuable to sometimes charge the battery overnight during off-peak hours? How can one ensure enough available capacity to consistently drive down monthly peak demands during a string of cloudy days?

Some of these questions around sizing can be answered by tools like CleanSpark's mVSO product that can model different combinations of DER. These tools use a library of equipment and a provided facility load profile to simulate equipment operation within a typical meteorological year to provide sample energy mix profiles like the charts shown above. These tools also provide detailed energy and cost savings metrics as well as overall financial projections.

But once the optimal mix of DERs has been established, microgrids require either local or cloud control to make the DERs behave in an optimal way under changing energy generation from the solar assets or fluctuating load as well as updates in the utility rate structures and incentive program rules. Control algorithms run the gamut from simple set-and-forget to those like CleanSpark's mPulse Max product, which uses patented forecasting techniques and advanced local intelligence to dynamically modify DER interaction due to changing weather, site, and utility conditions.

The bottom line is that energy storage can be a valuable addition to a renewable energy developer's toolkit and provide significant value to end consumers, utilities, and everyone in between.

About the Author:

Amanda Kabak, Chief Technology Officer, CleanSpark, Inc.

Amanda is an experienced technology professional with nearly a decade of hands-on and managerial experience in cloud-native and hybrid-cloud platforms. Before joining CleanSpark, Ms. Kabak was a managing consultant for 10th Magnitude, a cloud consulting company and valued Microsoft Partner. Prior to that, she was the Sr. Software Architect at OptiRTC, Inc., an industrial IoT company with a cloud-native platform focused on storm water management.

For More Information

Contact CleanSpark today for additional information or a free demo of our products.

info@cleanspark.com

+1 (866) 245-1772

www.cleanspark.com

i https://bit.ly/33mj2qT

ii https://www.eia.gov/todayinenergy/detail.php?id=34892

iii https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf